

THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATION

CH214 – APPLIED PHYSICAL CHEMISTRY

MONDAY 22nd JUNE 2020 - 12:50 PM

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES:

1. You will have 10 minutes to read the question paper. You **MUST NOT** begin writing in the answer book during this time.
2. **ANSWER ALL QUESTIONS.**
3. All answers **MUST** be written on the answer book provided.
4. Calculators are permitted in the examination room, **IF NECESSARY**. Lecture notes, notebooks, plain papers, and textbooks are **NOT** allowed.
5. Mobile phones are not allowed. **SWITCH OFF THE MOBILE PHONES.**
6. Show all working and calculations in the answer book.
7. **DRAW any FIGURES** clearly and visibly.
8. **DO NOT** over write
9. Write your name and number clearly on the front page of the answer book. **DO IT NOW.**

MARKING SCHEME: [TOTAL 50 MARKS]

1. Consider the thermodynamic data at 298K presented in the Table below:

	ΔH_f° kJ/mol	ΔG_f° kJ/mol	S_f° J/mol/K
$\text{Sr}(\text{IO}_3)_2$ (s)	-1019.2	-855.1	234
Sr^{2+} (aq)	-545.8	-599.5	-32.6
IO_3^- (aq)	-221.3	-128.0	118.4

(a) Calculate the ΔG° for the reaction $\text{Sr}(\text{IO}_3)_2$ (s) \leftrightarrow Sr^{2+} (aq) + 2 IO_3^- (aq).

Show all calculations clearly. No short cut.

[4 marks]

(b) From your result in 1(a) above, what is the K_{sp} for $\text{Sr}(\text{IO}_3)_2$?

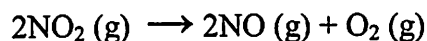
[2 marks]

(c) From your result in 1(b) above, what is the molarity of a saturated aqueous solution of $\text{Sr}(\text{IO}_3)_2$ at 298K?

[4 marks]

(TOTAL: 10 MARKS)

2. The equation for the thermal decomposition of NO_2 at 330°C is given below:



The change in concentration of NO_2 was studied over a period time, and the kinetics data is presented in the table below:

Time (s)	$[\text{NO}_2]$ (M)	$\ln[\text{NO}_2]$	$1/[\text{NO}_2]$ (M^{-1})
0	1.00×10^{-2}	-4.605	100
60	6.83×10^{-3}	-4.986	146
120	5.18×10^{-3}	-5.263	193
180	4.18×10^{-3}	-5.477	239
240	3.50×10^{-3}	-5.655	286
300	3.01×10^{-3}	-5.806	332
360	2.64×10^{-3}	-5.937	379

- (a) Using the graph paper provided, plot a graph of $1/[\text{NO}_2]$ in M^{-1} on the vertical axis, against time (s) on the horizontal axis. Try and cover the entire area on the graph sheet.

[6 marks]

- (b) Based on the nature of the graph, what is the order of the reaction?

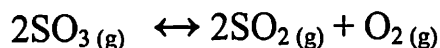
[2 marks]

- (c) From 2(a) above, calculate the rate constant, k for the reaction.

[4 marks]

(TOTAL: 12 MARKS)

3. The equilibrium condition for $\text{SO}_2(\text{g})$, $\text{O}_2(\text{g})$, and $\text{SO}_3(\text{g})$ is important in the production of sulfuric acid in industry. The equation for the reaction is given below:



When a 0.0200 mole sample of SO_3 is introduced into an evacuated 1.52 L reaction vessel at 900K, 0.0142 mole SO_3 was present at equilibrium.

- (a) Set up a complete ICE Table for the reaction showing all initial concentrations, changes that occurred for each substance, and equilibrium concentrations for each during the reaction.

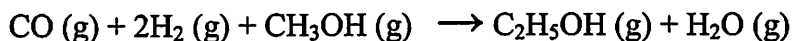
[5 marks]

- (b) From 3 (a) above, calculate the equilibrium constant K_c for the dissociation of $\text{SO}_3(\text{g})$ at 900K.

[3 marks]

(TOTAL: 8 MARKS)

4. A possible reaction for converting methanol to ethanol is as follows:



You are provided with the following thermodynamic data at 298K:

	ΔH_f° kJ/mol	ΔG_f° kJ/mol	S_f° J/mol/K
CO (g)	-110.5	-137.2	197.7
H ₂ (g)	0	0	130.7
CH ₃ OH (g)	-200.7	-162.0	239.8
C ₂ H ₅ OH (g)	-235.1	-168.5	282.7
H ₂ O (g)	-241.8	-228.6	188.8

- (a) Calculate ΔH° for the reaction at 298K. [4 marks]
- (b) Calculate ΔS° for the reaction at 298K. [4 Mark]
- (c) Calculate ΔG° for the reaction at 298K. [4 marks]
- (d) Calculate the K_p for the reaction at 750K [8 marks]
- (e) Is the reaction thermodynamically favoured at high, or low temperature? How do you know?

(TOTAL: 20 MARKS)

-----THE END-----

EQUATIONS SHEET

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = -RT \ln K_p$$

$$\ln K_2 - \ln K_1 = \frac{\Delta H^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$\frac{1}{[A]_t} = akt + \frac{1}{[A]_o}$$

$$[A]_t = -akt + [A]_o$$

$$\ln[A]_t = -akt + \ln[A]_o$$

$$R = 8.314 \text{ J mol}^{-1}\text{K}^{-1}$$